**IRAQI BULLETIN OF GEOLOGY AND MINING (IBGM)\
IRAQ GEOLOGICAL SURVEY (GEOSURV-IRAQ)**

Vol.20, No.2, 2024 ***p 39 – 47***

PALEOCLIMATE EVIDENCE USING CALCAREOUS NANNOFOSSILS FROM MUSHORAH FORMATION IN NORTHWESTERN IRAQ

Basma M. Al-Taaie[1] **and Omar A. Al-Badrani**[1]*

[1] Department of Geology, College of Science, Mosul University, Iraq, *Correspondence e-mail: omarbadrani@uomosul.edu.iq

Type of the Paper: Article
Received: 18/ 04/ 2023
Accepted: 16/ 08/ 2023
Available online: November 06, 2024

Keywords: Campanian; Mushorah Formation; Calcareous Nannofossils; Iraq.

ABSTRACT

Calcareous nannofossils are classified from the Mushorah Formation from two subsurface sections in Butmah 15-well, Butmah oil field, and Sfaia 41-well, Sfaia oil field, Northwestern Iraq. This Nannopaleontological classification of these calcareous nannofossils led to the determination of many species. Calcareous nannofossils are dominated by the following taxon: Chiastozygaceae family with two of the *Chiastozygus* genus, three species of the *Reinhardtites* genus and three species of the Z*eugrhabdotus* genus, Axopodorhabdaceae family with one species of the *Cribrocorona* genus, Eiffellithaceae family with two of the *Eiffellithus* genus, Prediscosphaeraceae family with two of the *Prediscosphaera* genus, Cretarhabdaceae family with two of the *Retecapsa* genus, Rhagodiscaceae family with two of the *Rhagodiscus genus,* Watznaueriaceae family with two of the *Cyclagelosphaera* genus, with five of the *Watznaueria* genus, Arkhangelskiales family with two of the, *Arkhangelskiella* genus, with two of the *Broinsonia* genus, one of the *Misceomarginatus* genus, Calyptrosphaeraceae family with three of the *Calculites* genus with one of the *Lucianorhabdus genus*, Microrhabdulaceae family with three of the *Lithraphidites* genus, Polycyclolithaceae family with four of the *Eprolithus* genus, with three of the *Lithastrinus* genus, with five of the *Micula* genus, two of the *Quadrum* genus, one of the *Rucinolithus genus*, three of the *Ceratolithoides* genus.

Our investigation focuses on the response of the assemblage of the *Watznaueria* spp., it can be concluded from higher speciation for calcareous nannofossils that the bloom at Campanian has an increase in temperature has implications for climate change impacts on the ecosystem.

1. INTRODUCTION

At the Mushorah well's type section (1), the Mushorah Formation is mainly composed of recrystallized alligostiganal limestone and limestone (Bellen et al., 1959). However, Hart (1962) established the Mushorah Formation's limits and established that the Wajna Formation underlying it in several wells in the regions of northwest Iraq (Buday, 1980). Mushorah Formation is equivalent to the Lower part of the Balambo Formation (Ghafor, 1993) and (Karim & Ghafoor, 2000), to the upper part of the Kometan Formation (Ghafor et al., 2004), to the upper part of the Hartha Formation (Ghafor, 1988).

Haddad & Amin (2007) did research in northern Iraq on the Upper Turonian to Lower Campanian sedimentary cycle's Mushorah Formation (Diagram.1), (Khalaf et al., 2014) analyzed the Mushorah Formation's lithostratigraphy, and (Hassan et al., 2021) examined its biostratigraphy, there are many studies for this formation as (Al-Haj, 2011) (Al-Haj et al., 2018).

The study area is located in the Foothill Zone of the Unstable Shelf of the Arabian platform. The first section from the Butmah oil field (Bu15) and the second section from the Sfaia oil field (Sf41) are located northwest of Mosul city in northern Iraq (Buday, T., and Jassim, 1987) (Figure 1).

The remains of the sea surface-dwelling coccolithophores algae are known as calcareous nannofossils. They float close to the water's top because they need sunlight to carry out photosynthesis. These algae produce microscopic tests known as coccospheres, which are made up of platelets that sink to the ocean's floor. At this time, they are producing a significant amount of sediments on the ocean floor, and their weight is sufficient to compress the lowest sediments into rocks.

The purpose of this study is to classify the calcareous nannofossils and investigate the paleoclimate of the study wells.

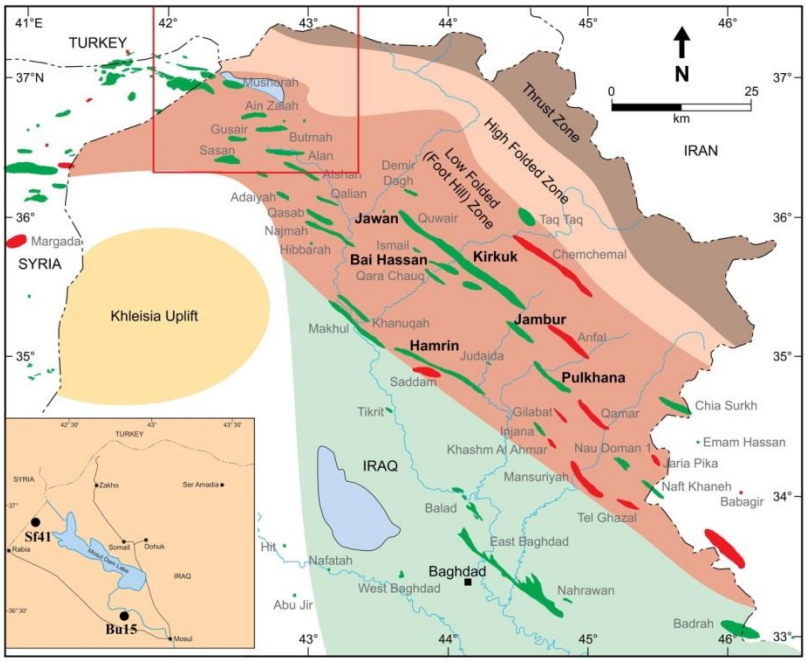

Figure 1: Tectonic map showing the studied section (After Al-Qayim et al., 2010 and Al-Mutwali et al., 2008)

2. MATERIALS AND METHODS

Data for this study was generated from sixteen samples of cutting samples from the Mushorah Formation. Samples were collected at different intervals, which were obtained from one well namely (Bu15) and (Sf41), with Lithologic mainly from Limestone. The Laboratory Analysis Nannofossil Slides preparation is made by using the method (H) (Armstrong, H. and Brasier, 2005).

3. RESULTS AND DISCUSSIONS

The Nannopaleontology of the calcareous nannofossils depends on many paleontological references (Bown & Young, 1997) and (Perch-Nielsen, 1985) to identify fifty-four species of calcareous nannofossils (Figures 2-6). The materials are stored in the Dept. of Geology, Science College, University of Mosul, Mosul, Iraq.

3.1. Nannopaleontology

3.1.A. Heterococcolith

1. **Family Chiastozygaceae:**
   Chiastozygus (*Chiastozygus litterarius*, *Chiastozygus* sp.), *Reinhardtites* (*Reinhardtites anthophorus*, *Reinhardtites elkefensis*, *Reinhardtites levis*), *Zeugrhabdotus* (*Zeugrhabdotus acanthus*, *Zeugrhabdotus embergeri*, *Zeugrhabdotus* sp.).
2. **Family Axopodorhabdaceae:**
   Cribrocorona (*Cribrocorona cf. echinus*).
3. **Family Eiffellithaceae:**
   Eiffellithus (*Eiffellithus collis*, *Eiffellithus gorkae*).
4. **Family Prediscosphaeraceae:**
   Prediscosphaera (*Prediscosphaera cretacea*, *Prediscosphaera grandis*).
5. **Family Cretarhabdaceae**
   Retecapsa (*Retecapsa angustiforata*, *Retecapsa crenulata*).
6. **Rhagodiscaceae:**
   Rhagodiscus (*Rhagodiscus angustus*, *Rhagodiscus splendens*).
7. **Family Watznaueriaceae:**
   Cyclagelosphaera (*Cyclagelosphaera wiedmannii*, *Cyclagelosphaera* sp.), *Watznaueria* (*Watznaueria barnesiae*, *Watznaueria bayackii*, *Watznaueria biporta*, *Watznaueria britannica*, *Watznaueria quadriradiata*).
8. **Family Arkhangelskiales:**
   Arkhangelskiella (*Arkhangelskiella specillata*, *Arkhangelskiella* sp.) *Broinsonia* (*Broinsonia enormis*, *Broinsonia parca*) *Misceomarginatus* (*Misceomarginatus pleniporus*).

3.2.B. Holococcoliths

1. **Family Calyptrosphaeraceae:**
   Calculites (*Calculites obscurus*, *Calculites ovalis*, *Calculites* sp.), *Lucianorhabdus* (*Lucianorhabdus cf. maleformis*)

3.3.C. Nannoliths

1. **Family Microrhabdulaceae:**
   Lithraphidites (*Lithraphidites houghtonii*, *Lithraphidites magnus*, *Lithraphidites praequadratus*)
2. **Family Polycyclolithaceae:**
   Eprolithus (*Eprolithus antiquus*, *Eprolithus apertior*, *Eprolithus floralis*, *Eprolithus* sp.), *Lithastrinus* (*Lithastrinus grillii*, *Lithastrinus septenarius*, *Lithastrinus* sp.), *Micula* (*Micula adumbrata*, *Micula clypeata*, *Micula cubiformis*, *Micula staurophora*, *Micula swastica*), *Quadrum* (*Quadrum bengalensis*, *Quadrum* sp.), *Rucinolithus* (*Rucinolithus wisei*), *Ceratolithoides* (*Ceratolithoides amplector*, *Ceratolithoides dongenii*, *Ceratolithoides prominens*).

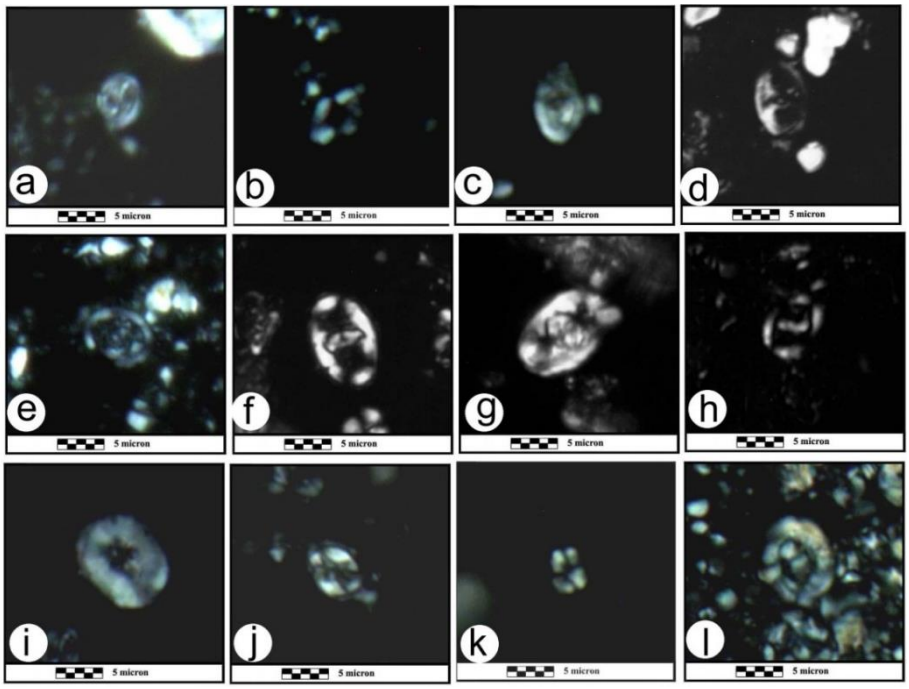

Figure 2: Polarized micrographs of calcareous nannofossil from the Mushorah Formation.
a) *Chiastozygus litterarius* ; **b)** *Chiastozygus* sp.; **c)** *Reinhardtites anthophorus*;
d) *Reinhardtites elkefensis*; **e)** *Reinhardtites levis*; **f)** *Zeugrhabdotus acanthus*;
g) *Zeugrhabdotus embergeri*; **h)** *Zeugrhabdotus* sp.; **i)** *Cribrocorona cf. echinus*;
j) *Eiffellithus collis*; **k)** *Eiffellithus gorkae*; **l)** *Prediscosphaera cretacea*.

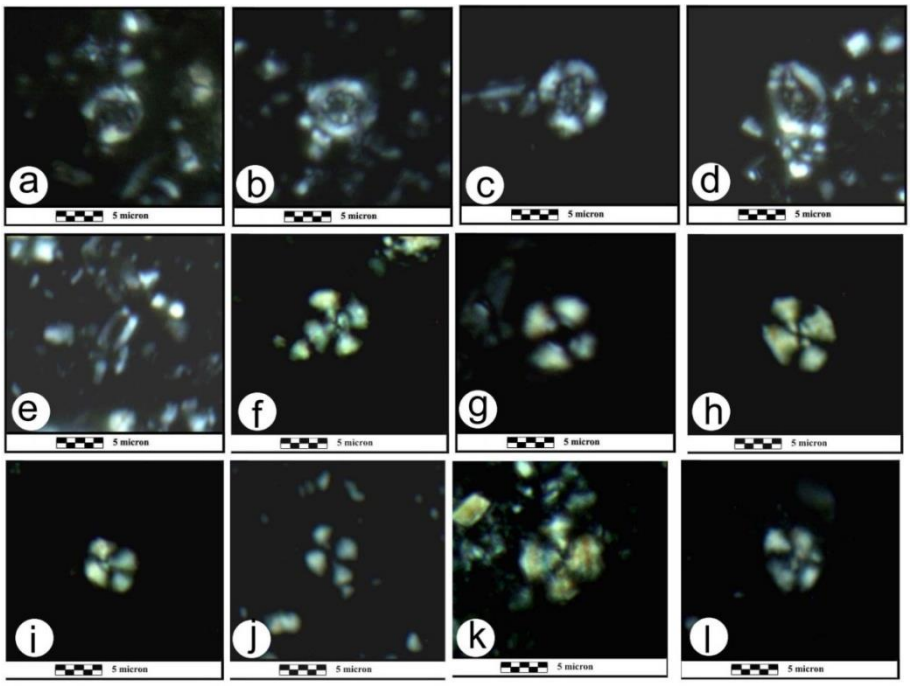

Figure 3: Polarized micrographs of calcareous nannofossil from the Mushorah Formation.
a) *Prediscosphaera grandis*; **b)** *Retecapsa angustiforata*; **c)** *Retecapsa crenulata*;
d) *Rhagodiscus angustus*; **e)** *Rhagodiscus splendens*; **f)** *Cyclagelosphaera wiedmannii*;
g) *Cyclagelosphaera* sp.; **h)** *Watznaueria barnesiae*; **i)** *Watznaueria bayackii*; **j)** *Watznaueria biporta*; **k)** *Watznaueria britannica*; **l)** *Watznaueria quadriradiata*.

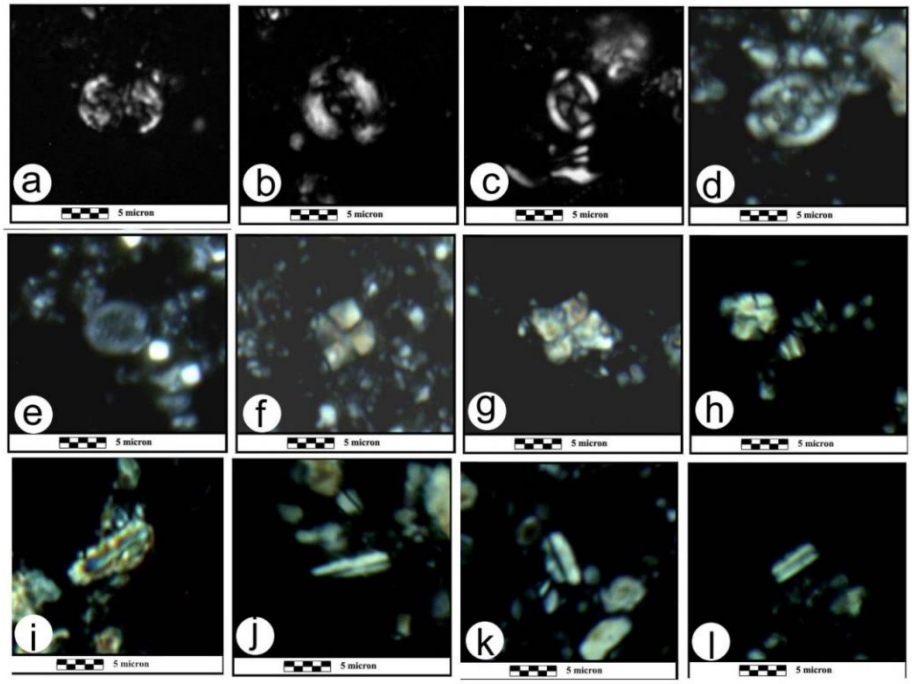

Figure 4: Polarized micrographs of calcareous nannofossil from the Mushorah Formation.
a) *Arkhangelskiella specillata*; **b)** *Arkhangelskiella* sp.; **c)** *Broinsonia enormis*; **d)** *Broinsonia parca*; **e)** *Misceomarginatus pleniporus*; **f)** *Calculites obscurus*; **g)** *Calculites ovalis*; **h)** *Calculites* sp.; **i)** *Lucianorhabdus cf. maleformis*; **j)** *Lithraphidites houghtonii*; **k)** *Lithraphidites magnus*; **l)** *Lithraphidites praequadratus*.

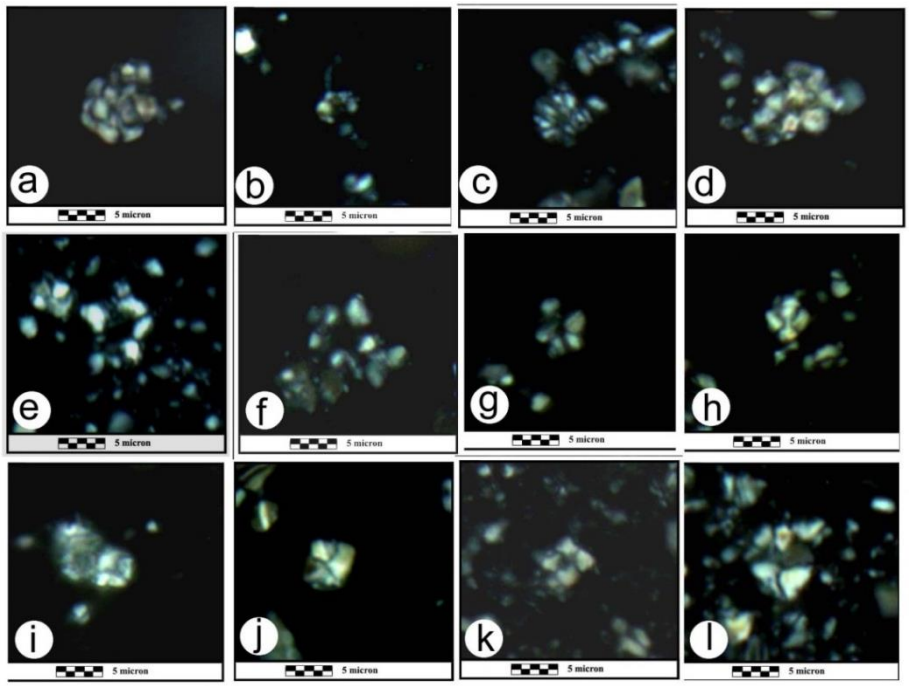

Figure 5: Polarized micrographs of calcareous nannofossil from the Mushorah Formation.
a) *Eprolithus antiquus*; **b)** *Eprolithus apertior*; **c)** *Eprolithus floralis*; **d)** *Eprolithus* sp.; **e)** *Lithastrinus grillii*; **f)** *Lithastrinus septenarius*; **g)** *Lithastrinus* sp.; **h)** *Micula adumbrata*; **i)** *Micula clypeata*; **j)** *Micula cubiformis*; **k)** *Micula staurophora*; **l)** *Micula swastica*.

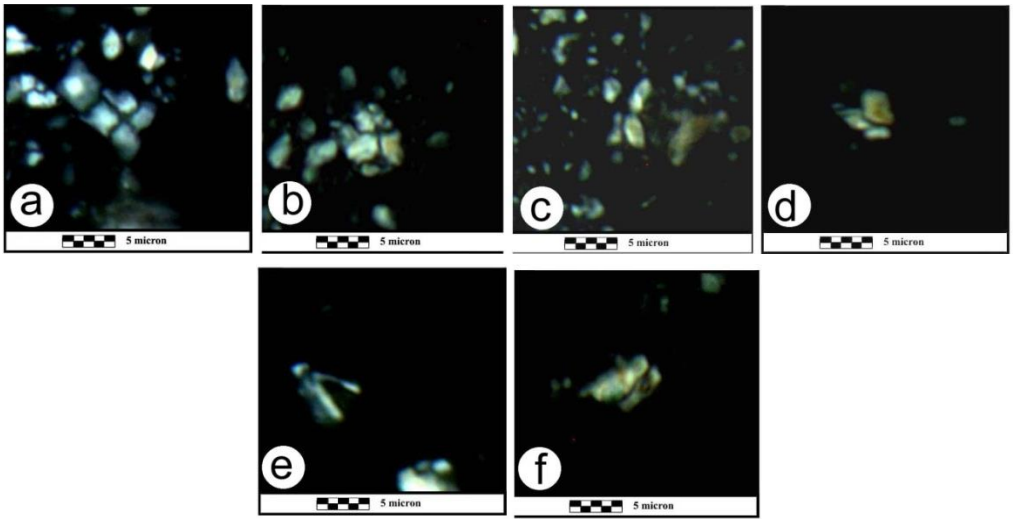

Figure 6: Polarized micrographs of calcareous nannofossil from the Mushorah Formation. **a)** *Quadrum bengalensis*; **b)** *Quadrum* sp.; **c)** *Rucinolithus wisei*; **d)** *Ceratolithoides amplector*; **e)** *Ceratolithoides dongenii*; **f)** *Ceratolithoides prominens*.

4. PALEOCLIMATOLOGY

Golden-brown, unicellular marine algae are called coccolithophores. Throughout their lifecycle, coccoliths, or extremely minute calcium carbonate scales, are produced. Since the late Triassic, this group has been a significant source of calcite in the open sea. These algae have become more popular because they are essential to the global carbon cycle. Heterococcolith is the most common type of coccolith. They are mainly composed of crystal units that might vary in size and shape. The holococcolith, another less uncommon type, comprises numerous tiny crystallites that seem to calcify the extracellular environment (Bown, 1998).

Our research focuses on how calcareous nannoplankton responds to paleoclimatology using data from the Mushorah Formation in Northwestern Iraq. The *Watznaueria* species exhibit nannofossil assemblage fluctuations. Based on the higher speciation of calcareous nannofossils, it can be inferred that the Campanian bloom has implications for the effects of climate change on ecosystems, suggesting potentially similar long-term changes to nannoplankton community structure as the oceans warm (Figures 7 – 10).

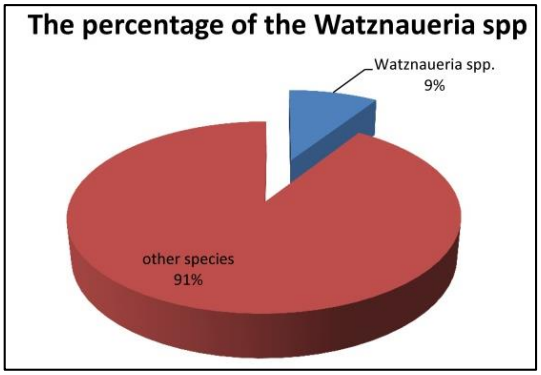

Figure 7: The percentage of the *Watznaueria* spp. in Bu15 well.

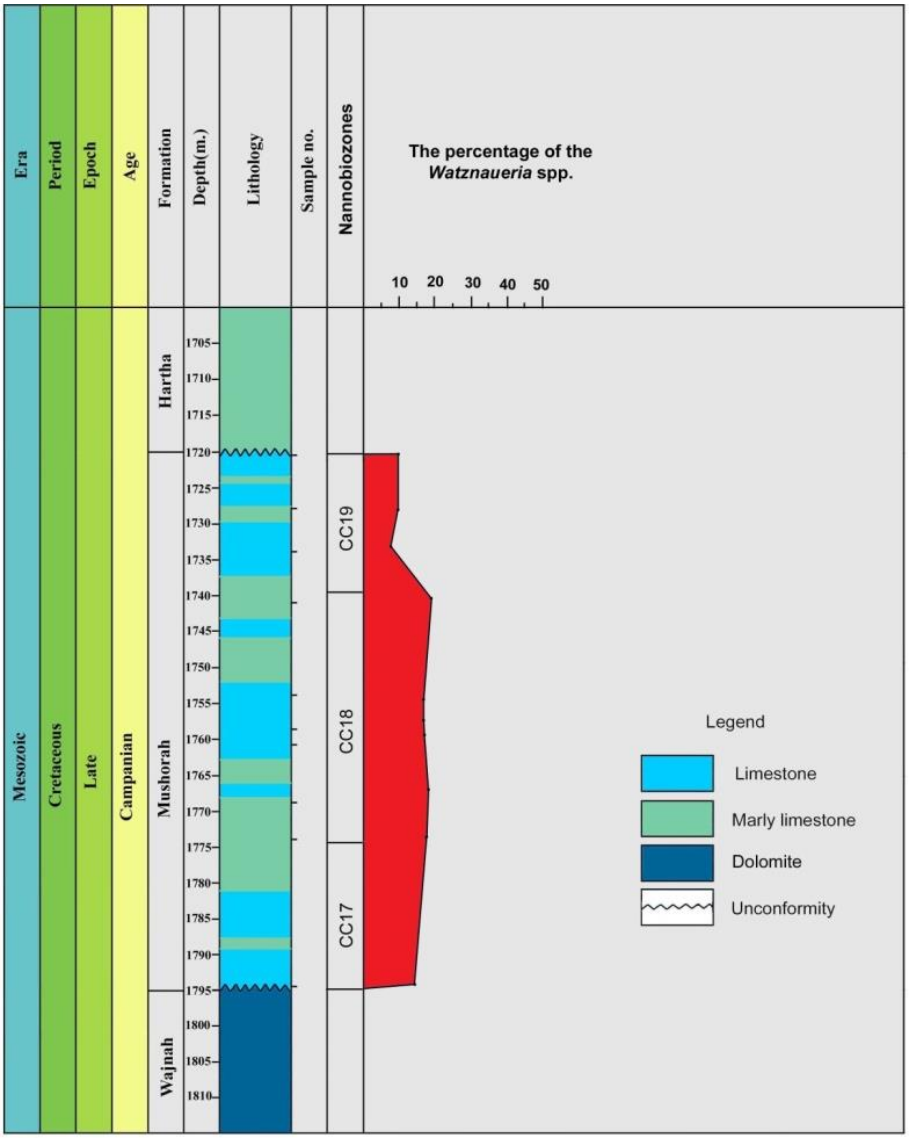

Figure 8: The percentage of the *Watznaueria* spp. in Bu15 well.

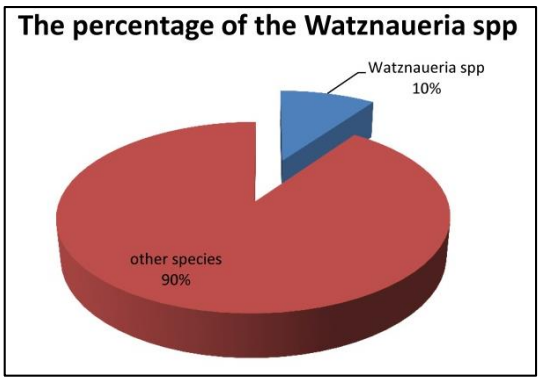

Figure 9: the percentage of the *Watznaueria* spp. in Sf 41well.

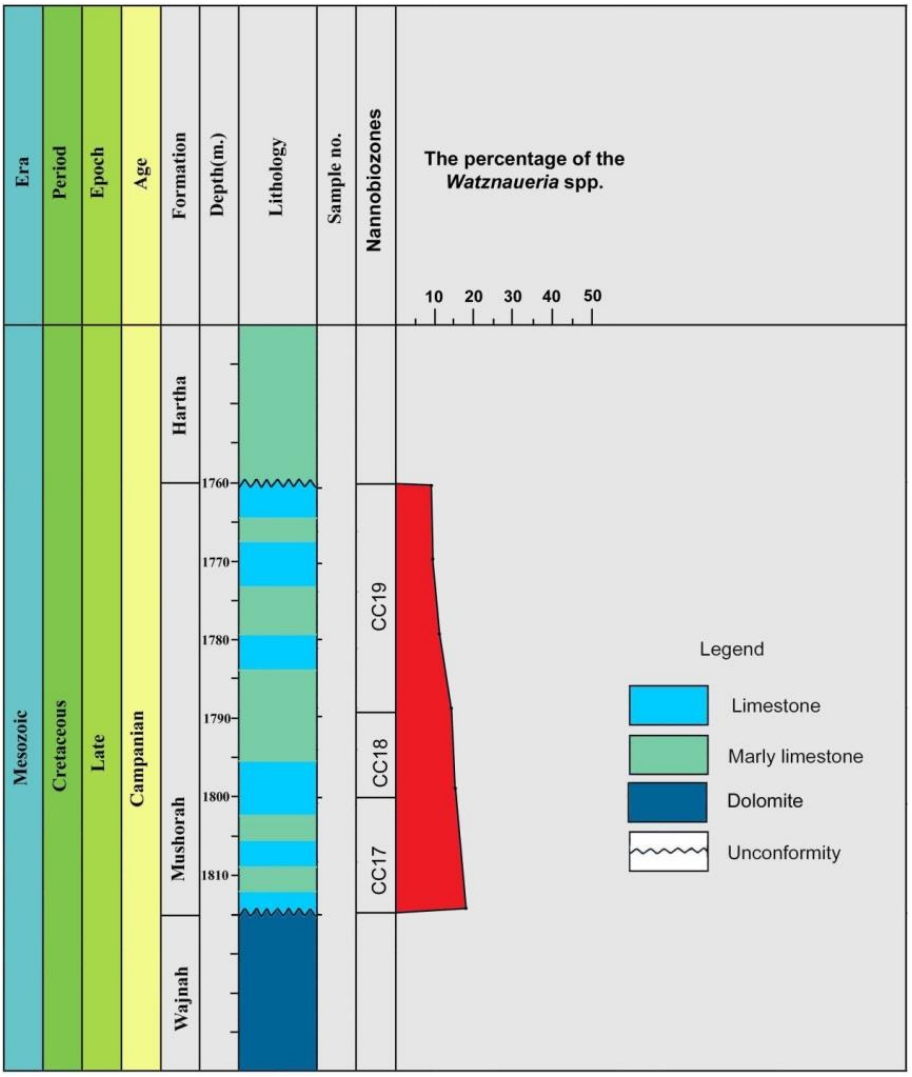

Figure 10: the percentage of the *Watznaueria* spp. in Sf 41 well.

5. CONCLUSIONS

According to the results of this study, the Mushorah Formation contains several species of Cretaceous calcareous nannofossils by the following taxon: Two species of *Chiastozygus*; three species of the *Reinhardtites*; three species of the Z*eugrhabdotus*; one species of the *Cribrocorona*; two of the *Eiffellithus*; two of the *Prediscosphaera*; two of the *Retecapsa*; two of the *Rhagodiscus*; two of the *Cyclagelosphaera*; five of the *Watznaueria*; two of them, *Arkhangelskiella*; two of the *Broinsonia*; one of the *Misceomarginatus*; three of the *Calculites*; one of the *Lucianorhabdus*; three of the *Lithraphidites*; four of the *Eprolithus*; three of the *Lithastrinus;* five of the *Micula*; two of the *Quadrum*; one of the *Rucinolithus*; three of the *Ceratolithoides*. That suggests the Early to Middle Campanian age for the study sections and concluded that the Mushorah Formation was deposited in tropical to subtropical areas.

ACKNOWLEDGMENTS

The writers are very grateful for the resources provided by the College of Science and the University of Mosul, which helped to raise the standard of this study.

REFERENCES

Al-Haj, M. A. (2011). *Study of sedimentary basin evolution of Cretaceous (Cenomanian-Early Campanian) succession north western Iraq.* PhD thesis at the University of Mosul.

Al-Haj, M. A., Al-Juboury, A. I., Al-Hadidy, A. H., & Hassan, D. K. (2018). Cenomanian-early Campanian carbonate reservoir rocks of northwestern Iraq: diagenesis and porosity development. *Al-Kitab Journal for Pure Sciences*, *2*(2), 1–19.

Al-Mutwali, M. M., Al-Banna, N. Y., & Al-Ghrear, J. S. (2008). Microfacies and sequence stratigraphy of the Late Campanian Bekhme Formation in the Dohuk area, north Iraq. *GeoArabia*, *13*(1), 39–54.

Al-Qayim, B., Qadir, F. M., & Albeyati, F. (2010). Dolomitization and porosity evaluation of the Cretaceous Upper Qamchuqa (Mauddud) Formation, Khabbaz oil field, Kirkuk area, northern Iraq. *GeoArabia*, *15*(4), 49–76.

Armstrong, H. and Brasier, M. (2005). *Microfossils*. Black well publishing.

Bellen, R. C. van, Dunnington, H. V, Wetzel, R., & Morton, D. M. (1959). Lexique stratigraphique international Asia, fascicule, 10a, Iraq. *Center National de La Recherché Scientifique, Paris*, *33*, 333.

Bown, P. R. (1998). *Calcareous Nannofossil Biostratigraphy*. BritishBritish Micropalaeontological Society Publication Series. Chapman and Hall.

Bown, P. R., & Young, J. R. (1997). Mesozoic Calcareous Nannoplankton Classification. *Journal of Nannoplankton Research*, *19*(1), 21–36.

Buday, T., and Jassim, S. Z. (1987). *The Regional Geology of Iraq. Vol. 2. Geological survey and mineral investigation*.

Buday, T. (1980). *The Regional Geology of Iraq: Stratigraphy and paleogeography* (I. M. Kassab, Ismail & Z. Jassim, Saad (eds.)). Iraqi Geological Survey.

Ghafor, I. M. (1988). *Planktonic foraminifera and biostratigraphy of the Aaliji Formation and the nature of its contact with the Shiranish Formation in Well Tel - Hajar No.1, Sinjar area, Northwestern Iraq*. University of Salahaddin, Iraq.

Ghafor, I. M. (1993). Planktonic foraminifera ranges in the Balambo Formation (Albian – Turonian) in Sulaimaniya, Azmer region northeastern Iraq. *Second Scientific Congress, 24–25 April 1993, Special Issue, Arbil, Iraq*, 30–40.

Ghafor, I. M., Sharbazheri, K. M. I., & Ahmad, S. Q. (2004). Biostratigraphy of the Balambo Formation (late Aptian-Turonian) in Khamza valley, Qala Chwalan area, Northeastern Iraqi-Kurdistan region, Zanco. *The J Middle East Petroleum Geoscience*, *16*, 27–42.

Haddad, S. N. S., & Amin, M. A. (2007). Mid-Turonian–early Campanian sequence stratigraphy of northeast Iraq. *GeoArabia*, *12*(2), 135–176.

Hassan, F., Mohamed, W., Yunus, W., & Salih, A.-S. (2021). The study of lithology by using the cross-section profiles of the logs of Shiranish and Mushorah formations in Ain Zalah and Butmah fields, Northwestern Iraq. *Iraqi National Journal of Earth Science (INJES)*, *21*(1), 17–26.

K Khalaf, S., Y Al-Shareefi, I., & A Al-Eisa, M. (2014). Ostracode Biostratigraphy of Shiranish, Hartha and Mushorah Formations from Selected Boreholes Northwest and Central Iraq. *Iraqi National Journal of Earth Science*, *14*(1), 19–38.

Karim, K. H., & Ghafoor, I. M. (2000). Biostratigraphy of Upper part of Kolosh Formation from Sartaq Bamo area NE-Iraq. *Scientific Journal of Dohuk University*, *1*(1), 1–10.

Perch-Nielsen, K. (1985). *Mesozoic calcareous nannofossils* (P. stratigraphy In: Bolli, H. M., Saunders, J. B. and Perch-Nielsen, K.,(eds.) (ed.)). Cambridge University Press, Cambridge.

About the author

Omar Ahmed Al-Badrani is an Assistant Professor at the University of Mosul, Iraq. He obtained his B.Sc. degree in Geology in 1999, M.Sc. in Paleontology and Stratigraphy (2002), and Ph.D. in Paleontology and Stratigraphy (Nannostratigraphy) (2007) from the University of Mosul. He has been lecturing at the University of Mosul since 2002.

e-mail: omarbadrani@uomosul.edu.iq
Mailing address: University of Mosul, Mosul, Iraq